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EVENNESS AND HAIRINESS PROPERTIES OF VISCOSE MVS YARNS IN RELATION TO SOME M/C AND PROCESS PARAMETERS

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ABSTRACT

The consistency (by mean of evenness) and yarn surface integrity (by mean of the yarn hairiness) are main indices, which influence the appearance of final woven or knitted product. This study focuses on the effect of some m/c and process parameters on the evenness and hairiness properties of 100% viscose vortex spun yarns. Based on the Box and Behnken Design, MVS yarn samples were produced with three levels of yarn delivery speed, nozzle pressure and sliver hank. The technique of regression analysis of response surface was used to evaluate the yarn samples on the basis of yarn evenness, yarn hairiness (H), yarn hairiness variation (sH), thick places, thin places and neps per km. The results indicate that yarn uniformity initially increases and then decreases with the increase in the sliver hank. At low yarn delivery speed, yarn evenness decreases with the increase of nozzle pressure, but at high nozzle pressure, yarn evenness improves with the increase of yarn delivery speed. Yarn hairiness increases linearly with an increase in yarn delivery speed, and it decreases with an increase in nozzle pressure. Sliver hank influences the number of thick places remarkably and with the increase of sliver hank, number of thick places initially decreases and then increases.

KEYWORDS: Evenness, Hairiness, Nozzle Pressure, Sliver Hank, Vortex Yarns & Yarn Delivery Speed

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Original Article

INTRODUCTION

The consistency (by mean of evenness) and yarn surface integrity (by mean of the yarn hairiness) are main indices to measure the quality of yarns. The unevenness of yarns will deteriorate the mightiness of yarns, and increase the end breakage rate in the spinning, and the increase of the end breakage rate will directly limit the speed of the machines and reduce the productivity. In addition, the unevenness of yarns will seriously influence the appearance quality of textiles and there are levels of unevenness beyond which the yarn is unacceptable, whereas hairiness badly affect the knitting and post knitting processes. A number of machine and process parameters influence the fibre configuration and hence the yarn structure, which in turn affects the evenness and hairiness properties of vortex spun yarns. The present study focuses on the yarn delivery speed, nozzle pressure and sliver hank on the evenness and hairiness of mvs yarns. Some studies have been done regarding uniformity and hairiness properties of MVS yarns by different researchers[1-9], but the effect of process parameter namely sliver hank in interaction with yarn delivery speed and nozzle pressure is still unknown. According to Tyagi et al and Ortlek and Ulku, with the increase of nozzle pressure, yarn evenness deteriorates, and the number of thin, thick

places and neps increases, which was attributed to the fibre loss at higher nozzle pressure[1, 2]. Regarding hairiness, Tyagi et al[1, 10] observed an initial decrease followed by an increase in hairiness with the increase in nozzle pressure, whereas Ortlek and Ulku[3] found a continuous decreasing trend in hairiness with the increase in nozzle pressure. Basal and Oxenham [11] observed that higher nozzle pressure and smaller spindle diameter results lower hairiness. Regarding yarn evenness Tyagi et al[1] and Ortlek and Ulku[2] observed that yarn evenness deteriorates and the number of thin and thick places increases when a certain delivery speed is exceeded. Basal and Oxenham[11] observed lower number of thick places at lower yarn delivery speed. Kuppers et al[12] revealed that maximum and optimum delivery speeds with regard to yarn quality depend on the yarn count. They also stated that the ratio of air speed in the fibre guidance element and the yarn delivery speed should lie in the range of 12 to 19 for stable spinning process. So, there are both parallel and opposite findings in the available literature. The scanty literature present showing the influence of yarn delivery speed and nozzle pressure on evenness and hairiness characteristics of yarn and obscurity of the effect of third parameter i.e. sliver hank on these important characteristics of yarn stressed the need for the present study.

MATERIAL AND METHODS

Sample Preparation

100% viscose fibres were used to prepare yarn samples of 30 Ne on Murata Vortex Spinner No. 861 according to experimental plan as per the Box and Behnken design[13]. The actual values of three variables corresponding to the coded levels (Table 1) are given in Table 2.

Test Methods

Conditioning of all yarn samples was done for 48 hours in atmosphere of 20±2 ºc and 65±2 % RH before testing

Yarn Count

Yarn counts were determined by taking yarn lengths of 120 yards for each measurement by using cascade V (12.91) according to ASTM D6587 - 00 (2006) e1 standards.

Yarn Evenness, Imperfections and Hairiness

Yarns were tested for evenness, imperfections and hairiness (H) on Uster® Tester 5-S-400 (R 5.7). The number of thin places, thick places and neps were reported for 1000 meters with yarn speed 400 m/min and testing time of 1 min. The tests were performed in accordance with ASTM D1425 standard. The hairiness (H) and hairiness variation (sH) values were determined in accordance with ASTM D5647 standard. Yarn hairiness (H) value refers to degree of hairiness and informs about the count of fibres protruding from the yarn base, whereas yarn hairiness variation (sH) value is a measure of variation of the degree of hairiness. It is the standard deviation of the hairiness (H) values. Hairiness (H) may be sometimes beneficial like improving comfort, but Hairiness variation (sH) is always unwanted and smallest possible hairiness variation should be the desired goal, as it leads to shade variation, lowering the quality / appearance of garment.

Table 1: Experimental Plan for MVS Machine Variables Used for MVS Yarn Samples

Combination No.	Delivery Speed (x_1)	Nozzle Pressure (x_2)	Sliver Hank (x_3)
1	-1	-1	0
2	1	-1	0
3	-1	1	0
Table 1: Contd.,			
4	1	1	0

5	-1	0	-1
6	1	0	-1
7	-1	0	1
8	1	0	1
9	0	-1	-1
10	0	1	-1
11	0	-1	1
12	0	1	1
13	0	0	0
14	0	0	0
15	0	0	0

Table 2: Actual Values Corresponding to Coded Levels

Coded Level	Actual Values		
	Delivery Speed (X_1), M/Min	Nozzle Pressure (X_2), Mpa	Sliver Hank (X_3)
-1	370	0.4	0.14
0	400	0.5	0.16
1	430	0.6	0.18

RESULTS AND DISCUSSIONS

Statistical Analysis

Experimental results for various properties of different MVS yarns were input into a computer statistical tool program MATLAB (version R2015a) to obtain the response surface equations, using forward step regression procedure. The response surface equations and the squared multiple correlation coefficients of MVS yarns are given in Table 3. The negative coefficient of a variable in a response surface equation indicates that a particular characteristic decrease with the increase in that variable, whereas a positive coefficient of the variable indicates an increase in the characteristic with the increase in variable. The sign and magnitude of the coefficients of the squared terms and interaction terms modify the trend. This is shown in the spatial diagrams (Figures 1-5) drawn from the response surfaces.

Table 3: Response Surface Equations for Yarn Characteristics

Characteristic	Response Surface Equation	Squared Multiple Regression Coefficient (R^2)
Yarn evenness (CVm %)	$13.61 - 0.26x_3 + 0.40x_3^2$	0.76
Yarn hairiness (H) (%)	$3.88 + 0.22x_1 +0.0025x_3- 0.11x_2x_3$	0.91
Yarn hairiness variation (sH) (%)	$0.99 +0.09 x_1 - 0.09x_2 - 0.03x_3 + 4.43E\text{-}02x_1^2$	0.95
Yarn thick places /Km	$32.51- 12.32x_3 + 16.73x_3^2$	0.71
Yarn neps /Km	$51.62 - 14.95x_1$	0.68

Yarn Evenness

The three dimensional response surfaces in Figure-1 depict the nature of the variation in yarn evenness of MVS yarns with the change in process parameters in air-vortex spinning of viscose yarns. The response surface equation in Table 3 clearly shows that sliver hank is the only parameter, which has statistically significant effect in influencing yarn evenness of MVS yarns. The effect of sliver hank on yarn evenness is nonlinear. There is high degree of correlation between the calculated and the experimental values as reflected by high value of R^2. As seen in Figure 1, yarn unevenness value first decreases rapidly with an increase in the sliver hank producing more even yarn, and then increases relatively

moderately as sliver hank is increased further. This may be explained by the fact that, by feeding finer sliver to produce the yarn of same count requires lower main draft ratio, which, in turn, leads to more controlled movement of fibres in main drafting zone, subsequently producing evener yarn. However, on further increasing of slivers hank more than 0.16, the main draft ratio becomes too low, making the drafting force in the drafting zone lower than the peak value basically achieved by the optimum draft level, which, in turn, causes poor fibre slipping performance. This lower main draft is not enough to acquire appropriate fibre arrangement along the yarn, subsequently producing uneven yarn.

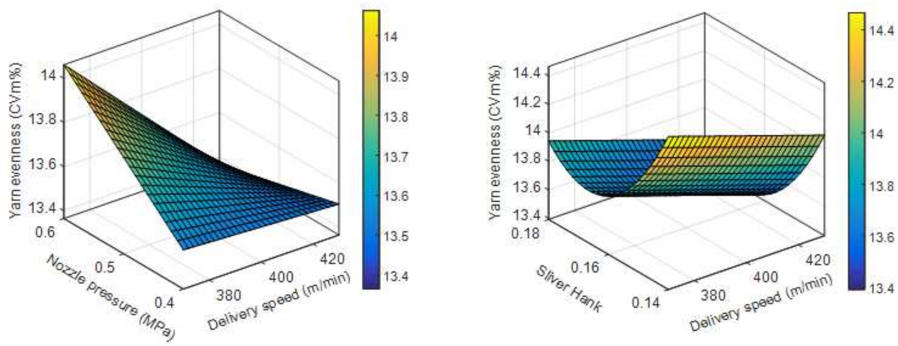

Figure 1: Response Surface Plots for the Effect of Process Variables on Yarn Evenness

Yarn Hairiness (H)

Response surface plots for the effect of process variables on yarn hairiness (H) is shown in Figure 2. It is clearly visible from response surface equation in Table 3 that yarn delivery speed is the most important parameter in influencing yarn hairiness (H) followed by sliver hank, which moderately affects yarn hairiness in interaction with nozzle air pressure. The value of R^2 indicates that 91 % of the variations in yarn hairiness (H) can be accounted for by these responses. In general, hairiness of yarns is more when spun at higher yarn delivery speed. This is due to the fact that at higher yarn delivery speed, more open end trailing fibres can't wrap yarn body well due to reduced staying time of fibres in nozzle block. It is evident from figure 2 that Hairiness (H) slightly reduces with an increase in the nozzle pressure due to better binding of the protruding fibres by increased wrapper fibres. However, the effect is less pronounced at lower sliver hank value and it becomes more pronounced as sliver hank is increased.

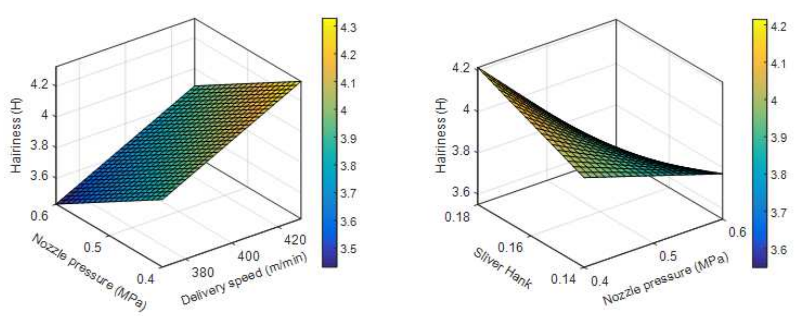

Figure 2: Response Surface Plots for the Effect of Process Variables on Yarn Hairiness

Yarn Hairiness Variation (sH)

Yarn hairiness variation (sH) represents variation in the degree of yarn hairiness. Response surface equation in

Table 3 shows the nature of variations in yarn hairiness variation (sH) of MVS yarns with the change in process parameters. The three-dimensional response surface maps (Figure 3) reveal that the yarn delivery speed is a critical factor associated with the change in yarn hairiness variation (sH) followed by nozzle pressure and sliver hank. The high value of R^2 indicates that 95% of variations in yarn hairiness variation (sH) can be accounted for by these responses. In general, the MVS yarns spun at higher yarn delivery speed show more variations in the degree of yarn hairiness. This is expectedly to be the consequence of decreasing efficiency of air flow, which increases irregular wrappings. On the other hand, yarn hairiness variation (sH) show a marked decrease with the increase in nozzle air pressure due to increased incidence of wrapper fibres and tight regular wrappings at higher nozzle air pressure. It is evident from figure 3 that there is slight decrease in variation in yarn hairiness, when finer slivers are fed owing to low main draft ratio in drafting zone.

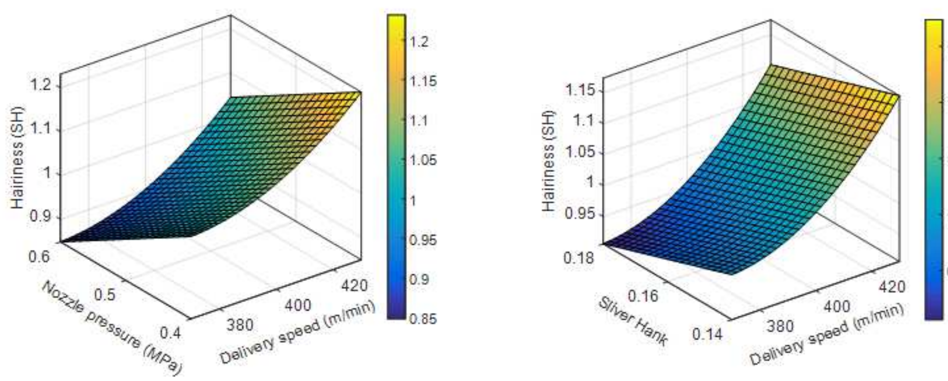

Figure 3: Response Surface Plots for the Effect of Process Variables on Yarn Hairiness Variation (Sh)

Thick Places

The effect of process parameters on thick places is shown in Figure 4. As noted from the response surface equation in Table 3, sliver hank is the only statistically important parameter and its effect is nonlinear. Further, there is no interaction term in the fitted correlation. The yarn delivery speed and nozzle pressure have no significant effect on thick places ($p>0.05$), as shown in response surface equation in Table-3. With an increase in the sliver hank from 0.14 to 0.16, thick places decrease which is expected to be the consequence of lower main draft ratio, leading to more control movement of fibres in drafting zone. However, when finer slivers of hank more than 0.16 are fed, the main draft ratio becomes very low, reducing the drafting force in the drafting zone, lower than the peak value basically achieved by the optimum draft level, causing poor fibre slipping performance. This lower main draft was not enough to acquire appropriate fibre arrangement along the yarn, thus slightly increasing the number of thick places in the yarn. As seen in Figure 4, thick places decrease linearly with an increase in nozzle pressure or delivery speed, however, the effect of delivery speed and nozzle pressure is not statistically significant as mentioned above.

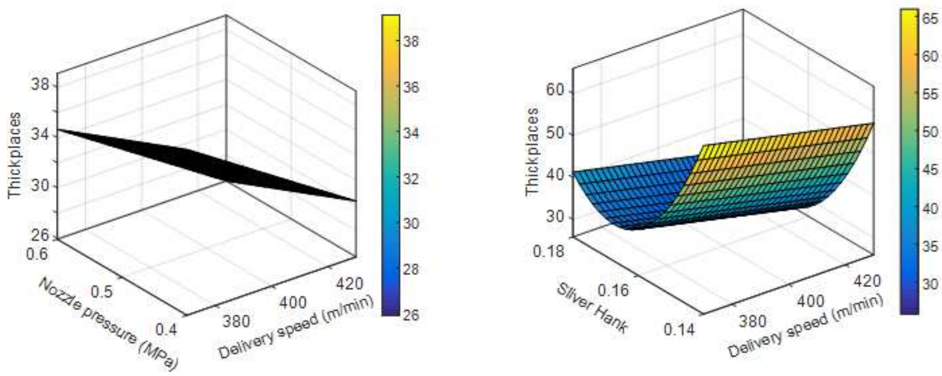

Figure 4: Response Surface Plots for the Effect of Process Variables on Yarn Thick Places

Neps

Effect of process variables on neps are shown in Figure - 5. It is clear from response surface equation in Table-3 that only yarn delivery speed has significant effect on number of neps/km of yarn. The effect of yarn delivery speed on number of neps/km of yarn is shown in Figure- 5. As the yarn delivery speed increases, number of neps/km of yarn decreases. From response surface equation in Table-3, it is clear that nozzle pressure and sliver hank have no significant effect ($P > 0.05$) on number of neps/km of yarn.

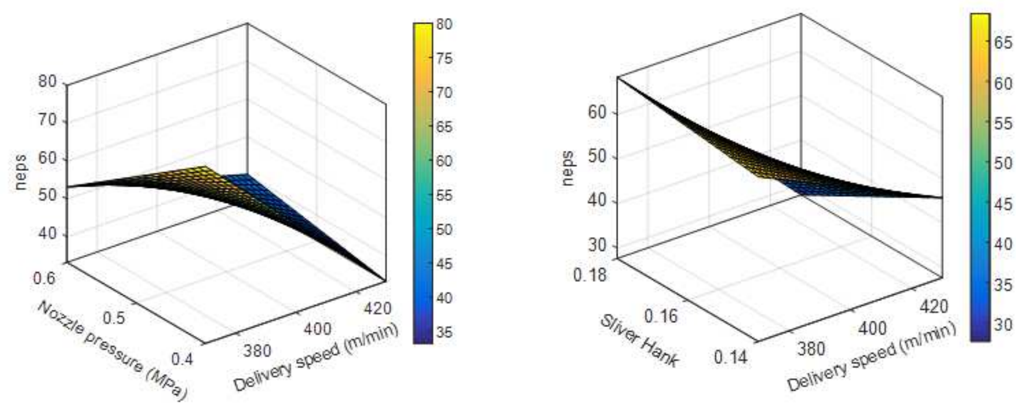

Figure 5: Response Surface Plots for the Effect of Process Variables on Yarn Neps

Thin Places

The squared multiple regression coefficient of response surface equation for thin places/km was very low, means the response surface equation cannot forecast exactly yarn thin places affected by yarn formation process parameters. So, no response surface plot or contour diagram was drawn for thin places/km.

CONCLUSIONS

The present study shows that Sliver hank is the most important and significant process variable, which effect yarn evenness and its effect is nonlinear. Yarn uniformity initially increases with the increase of sliver hank, and then decreases on further increase of sliver hank from 0.16 to 0.18. Yarn hairiness is influenced by yarn delivery speed and sliver hank. Hairiness of MVS yarns is more when spun at higher yarn delivery speed. Yarn hairiness increases linearly with an

increase in yarn delivery speed and it decreases slightly with an increase in nozzle pressure. There will be more variations in the degree of yarn hairiness of MVS yarns, when spun at higher yarn delivery speed or low nozzle air pressure. Sliver hank is the only statistically important process parameter, which affects thick places and its effect is nonlinear. Thick places initially decrease with the increase of sliver hank, and then increase on further increase of sliver hank from 0.16 to 0.18. As the yarn delivery speed increases, the number of neps per km of yarn decreases.

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